

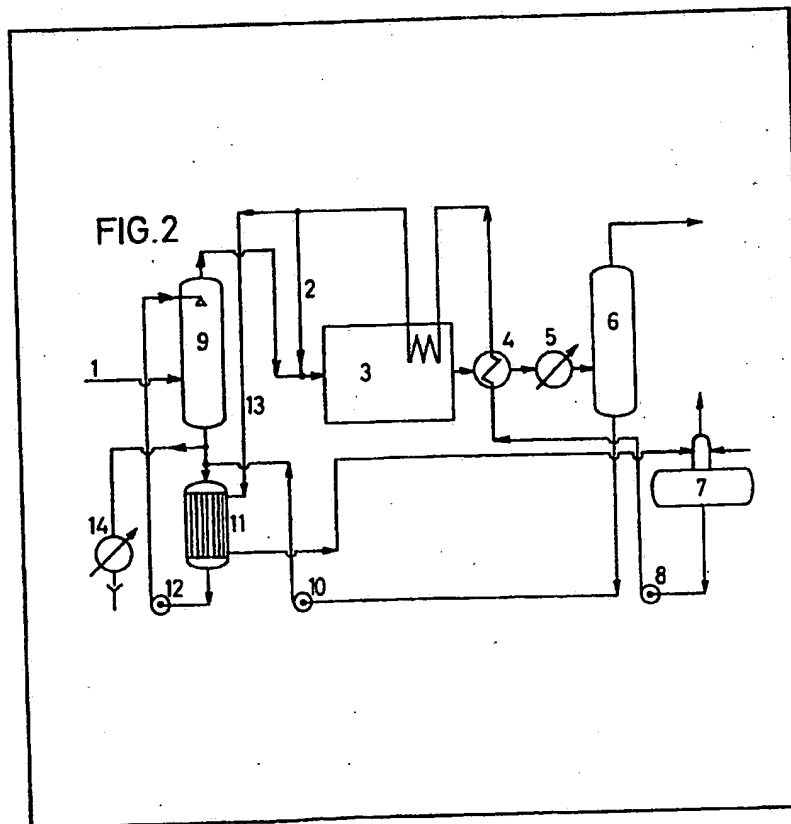
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(54) Emission-Free Use of Process Condensate in Steam Reforming Processes

(57) In the manufacture of synthesis
gas by steam reforming, a process
condensate containing small amounts
of by-products is produced and the
presence of these by-products causes

difficulties in the further use of the
condensate. The present invention
provides for a substantially emission-
free reuse of the process condensate,
with substantially complete recycle,
by heating the condensate by heat
exchange with condensing steam (11)
and employing the heated material for
the steam saturation of the gaseous
feedstock to be reformed (9).



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FIG.1

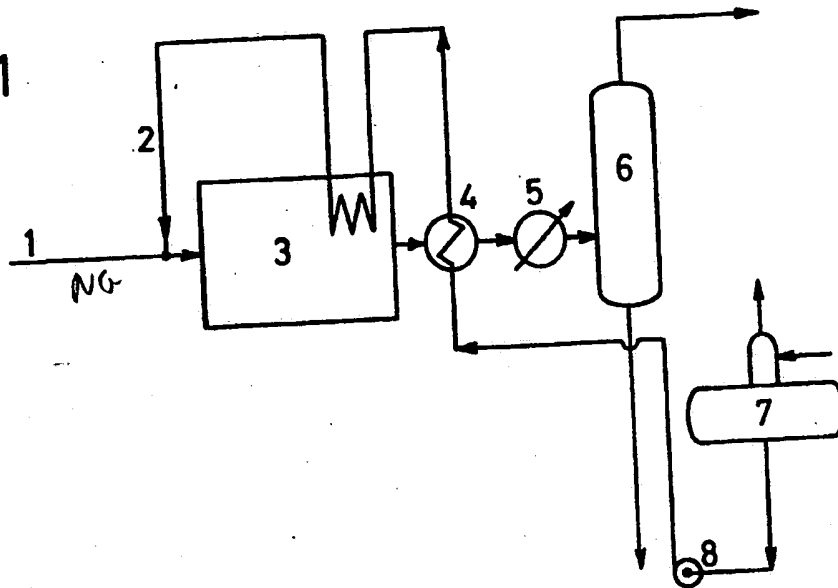
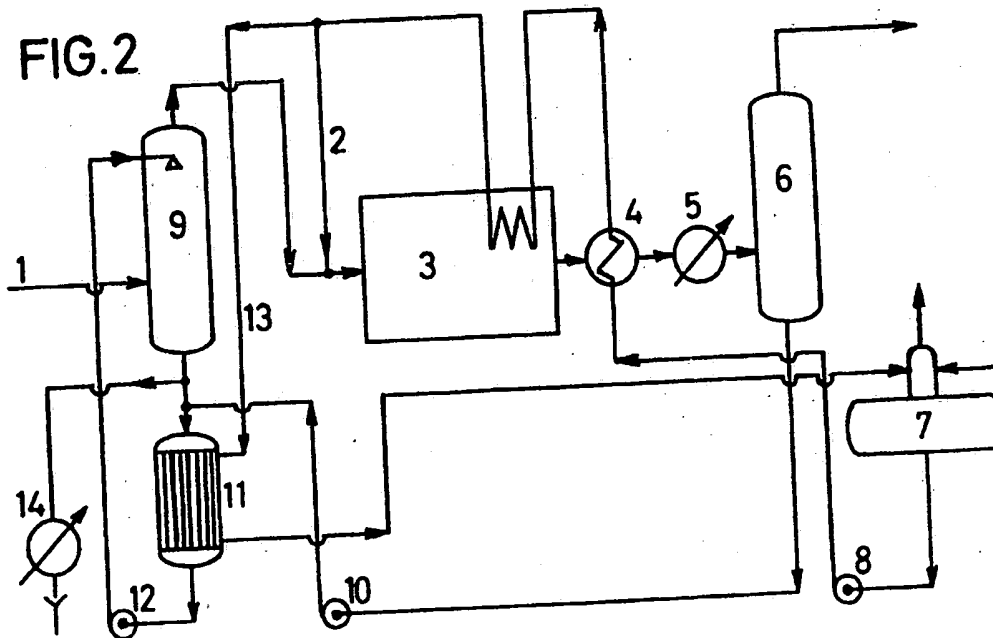
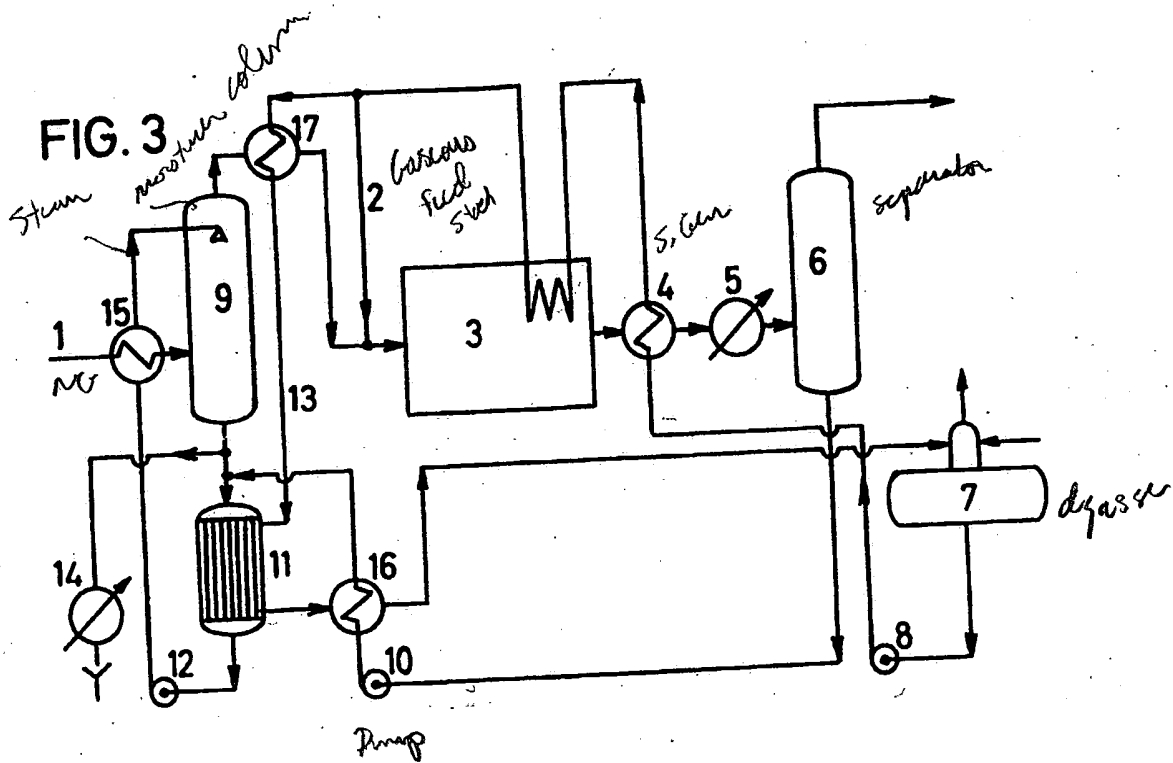


FIG.2



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SPECIFICATION

Emission-Free Reuse of Process Condensate in Steam Reforming Processes

In the manufacture of synthesis gas for the synthesis of ammonia or methanol by steam reforming, gaseous and/or liquid hydrocarbons are reacted with excess steam. In the further course of the process, this excess steam is condensed out of the process gas. The process condensate thus obtained contains small amounts of ammonia, carbon dioxide, methanol and other organic by-products. These by-products are undesirable if the process condensate is to be returned to the steam generating system as boiler feed, or if it is to be discharged as waste water. The conventional method of stripping the process condensate with steam leads to no improvement since the above by-products then pollute the atmosphere.

It is also known to wash the impurities out of the waste steam from the stripper and to recycle the resulting concentrate to the process. However, a disadvantage of such an arrangement is that it results in substantial heat consumption. Furthermore, process condensate worked up by stripping can only be used as boiler feed if the stripping is monitored very carefully.

We have found that these disadvantages are avoided and that in the steam reforming process, with substantially complete recycling of the process condensate, substantially emission-free reuse of process condensate is achieved if the latter is heated by heat exchange with condensing steam and is employed for steam-saturating the gaseous feedstock which is to be reformed.

In particular embodiments of the process of the invention, the process condensate is circulated by passing it successively through a steam-heated heat exchanger and a counter-current column through which gaseous feedstock flows for steam-saturation, or the process condensate is kept at the required temperature in the shell side of a steam-heated heat exchanger and is in direct contact with gaseous feedstock flowing through it. In a further embodiment, a loop reactor is employed. It can be advantageous to discharge a small proportion (e.g. up to 5%) of the process condensate in order to remove impurities. The process condensate to be discharged can be taken from the bottom of the column (when a counter-current column is used) and fresh process condensate can be fed into the circulation downstream from this outlet.

Further heat exchange can occur between the steam-heated process condensate and the gaseous feedstock prior to steam-saturation of the latter, between the separated process condensate and the steam condensate from the steam-heating of the process condensate, and between the steam-saturated gaseous feedstock and steam for the steam-heating of the process condensate.

Compared to conventional processes, the process of the invention has the advantage that

the process condensate is recycled to the process together with all volatile impurities, and that only slight heat losses occur.

It is a further advantage of the process of the invention that it can be carried out relatively simply in existing installations since the steam which in conventional methods was directly fed to the process can be used in part to heat and vaporize the process condensate.

The process of the invention and the prior art are illustrated by Figures 1 to 3 of the accompanying drawings:

Figure 1 of the drawings schematically shows a system for performing the prior art process. The gaseous feedstock, for example methane-rich natural gas or vaporized naphtha, enters through line 1. The steam required is generated in a steam generator 4 by means of waste heat from the process, and is fed to the gaseous feedstock through line 2. The gaseous feedstock, e.g. natural gas, and steam are reacted in a reactor 3 and are then cooled in steam generator 4 and in a condenser 5. Hereupon, the excess steam remaining in the gas condenses. The process condensate thus formed is collected in a separator 6 and is fed either to the waste water outlet or to a treatment unit. Fresh boiler feed for generating the total amount of steam required is introduced via a degasser 7 and a boiler feed pump 8. The water is vaporized in steam generator 4 and is superheated by means of waste heat from reactor 3. The conventional procedure is to generate the steam at a higher pressure and then to let it down to the pressure required in the process, whilst utilizing its work capacity. This detail has been omitted from the Figure.

Figure 2 of the drawings is a simplified schematic diagram of one installation operating in accordance with the invention. The gaseous feedstock, for example natural gas or naphtha, entering in gaseous form through line 1 is steam-saturated with steam in a counter-current moistener column 9, by spraying with a large amount of circulated hot process condensate, to the point that it takes up substantially the entire amount of process condensate which has formed in separator 6. Only the amount of steam stoichiometrically required for the reaction is added to the resulting mixture from moistener column 9 via line 2, i.e. the amount of steam additionally required for the gas-steam mixture from moistener column 9 to have, in total, the required steam content when entering reactor 3. The reaction in reactor 3, the generation of steam in steam generator 4, the cooling in condenser 5 and the separating-off of the process condensate in separator 6 are carried out in the same way as in the prior art method shown in Figure 1. The process condensate obtained in separator 6 is fed by means of a pump 10 to a circulation system for reuse. This system comprises moistener column 9, a steam-heated circulation heating unit 11 and a circulation pump 12. The pump circulates an amount of process condensate, which is several

times greater than the amount to be vaporized, through moistener column 9 and circulation heating unit 11. In the latter, the process condensate circulating in the circulation system is heated, by indirect heating with steam, by the same amount as that by which it has cooled on moistening gaseous feedstock in moistener column 9. The steam required for this purpose is supplied through line 13 from the same system which also supplies line 2 with steam. If necessary, a small amount of process condensate can be discharged from the circulation system via a condenser 14, in order to avoid accumulation of dissolved solids. Advantageously, this discharged material is taken off downstream from moistener column 9, where the content of volatile foreign materials is lowest. Figure 3 of the drawings shows a further installation for carrying out the process according to the invention, incorporating conventional measures for energy saving. Items 1—14 in Figure 3 are the same as in Figure 2. Additionally, a heat exchanger 15 is provided, in which the process condensate circulating in the circulation system is heated further by the heat of the hot gaseous feedstock coming from a pretreatment stage. A further heat exchanger 16 is provided, in which the process condensate flowing to the moistener circuit is heated by heat exchange with the steam condensate from the circulation heating unit 11, the heat from the steam condensate being substantially utilized. Yet another heat exchanger 17 is provided to utilize the fact that the steam flowing to the circulation heating unit 11 is superheated and thereby to heat the moistened gaseous feedstock further.

Example

In an ammonia plant, the stream of gaseous feedstock (methane) entering at 1 in Figure 2 of the drawings, at 300°C, amounts to 1,000 kmole/h. The amount of steam required for this stream of gas is 4,000 kmole/h. In the reformer and in the subsequent conversion, about 2,000 kmole/h (out of the total amount of steam) are converted. About 2,000 kmole/h of water are formed as process condensate. If the gaseous feedstock entering at 1 is under a pressure of 33 bars, it must leave the moistener at 218°C, corresponding to a partial pressure of steam of 22 bars. To achieve this, 13,500 kmole/h, i.e. 240 tonnes/h, of water are circulated through the moistener. The water enters the moistener at 235°C and leaves it at 170°C. The steam for direct introduction from line 2 is at a pressure of at least 33 bars. The corresponding saturated steam temperature of 239°C suffices to achieve a temperature of 235°C in the circulating process condensate in the circulation heating unit 11.

An advantage of the method described is that it can also be used in existing plants, for example

an ammonia plant, without an adverse effect on the steam balance.

Claims

1. A process for the substantially emission-free reuse of process condensate in the steam reforming process, with substantially complete recycling of the process condensate, wherein the process condensate is heated by heat exchange with condensing steam and is employed for the steam-saturation of the gaseous feedstock to be reformed.
2. A process as claimed in claim 1, wherein the process condensate is circulated, successively passing through a steam-heated heat exchanger and a counter-current column through which gaseous feedstock flows for steam-saturation.
3. A process as claimed in claim 1, wherein the process condensate is kept at the requisite temperature in the jacket of a steam-heated heat exchanger and is in direct contact with gaseous feedstock flowing through it.
4. A process as claimed in claim 1, wherein a loop reactor is employed.
5. A process as claimed in any of claims 1 to 4, wherein a small proportion of the process condensate is discharged in order to remove impurities.
6. A process as claimed in claim 5 as appendant to claim 2, wherein the process condensate to be discharged is taken from the bottom of the counter-current column and fresh process condensate is only introduced into the circulation downstream from this outlet.
7. A process as claimed in any of claims 1 to 6, wherein the condensate is additionally heated by heat exchange with the gaseous feedstock to be reformed prior to steam-saturation thereof.
8. A process for the manufacture of synthesis gas for the synthesis of ammonia or methanol comprising subjecting liquid or gaseous hydrocarbon material to steam reforming with excess steam, separating the excess steam by condensation from the gas produced to form a process condensate, heating the process condensate by heat exchange with condensing steam and contacting the gaseous feedstock with the heated process condensate to saturate it with steam, substantially the entire process condensate being reused substantially without emission to the atmosphere or environment.
9. A process as claimed in claim 8, wherein the reuse of the process condensate is achieved by a process as claimed in any of claims 2 to 7.
10. A process as claimed in claim 1 or 8 carried out substantially as hereinbefore described with reference to Figure 2 or Figure 3 of the accompanying drawings or as illustrated in the foregoing Examples.
11. An apparatus for performing the process claimed in claim 8 and substantially as illustrated

In Figure 2 or Figure 3 of the accompanying drawings.

synthesis gas manufactured by a process as
5 claimed in any of claims 8 to 10.

12. Ammonia or methanol when made from

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